CLAIMS

What is claimed is:

1. A low density parity code (LDPC) decoding apparatus performing LDPC decoding of a codeword formed by c code bits transmitted through a channel, the apparatus comprising:

a first Q matrix generation unit receiving the codeword and a p x c parity check matrix formed of 0 and 1 values, comprising the codeword with each of p rows of the parity check matrix formed of c elements, replacing the element having a value of 1 in each of the p rows with a code bit value in a location of the codeword corresponding to the location of the c element, and generating a first Q matrix;

an R matrix generation unit receiving the first Q matrix from the first Q matrix generation unit, and by using a first minimum value that is a minimum value among the elements that are not 0 in each row, a second minimum value that is a second minimum value in the same row, and the location of the first minimum value in each row of the first Q matrix, replacing the element that is not 0 in the row with the minimum value, among the remaining elements that are not 0 in the row excluding the value of the element, and generating an R matrix;

a second Q matrix generation unit receiving the codeword and the R matrix from the R matrix generation unit, generating a second Q matrix by replacing each non-zero element in the R matrix with a value obtained by adding all non-zero elements in the column having the non-zero element being replaced, except the non-zero element which is being replaced, and the element in the same column of the codeword, and outputting the second Q matrix to the R matrix generation unit; and

an output calculation unit receiving the R matrix from the R matrix generation unit and by determining one code bit by adding elements of each column of the R matrix, outputting a decoded codeword formed by the c code bits,

wherein the R matrix generation unit receives the second Q matrix from the second Q matrix generation unit, generates a second R matrix and outputs the second R matrix to the second Q matrix generation unit and the output calculation unit.

2. The LDPC decoding apparatus of claim 1, wherein the R matrix generation unit comprises:

a matrix element checking unit checking the elements that are not 0 in each row of the first Q matrix, and determining the first minimum value, the location of the first minimum value, and the second minimum value; and

a matrix element determination unit receiving the first Q matrix, and the first minimum value, the location of the first minimum value, and the second minimum value that is the second smallest value, of each row of the first Q matrix from the matrix element checking unit, wherein if the location is not the location of the first minimum value of the element that is not 0 of each row of the first Q matrix, the matrix element determination unit replaces the element with the first minimum value and, if the location of an element is the same as the first minimum value, replaces the element with the second minimum value, and generates the R matrix.

3. The LDPC decoding apparatus of claim 1, wherein the R matrix generation unit and the second Q matrix generation unit repeatedly perform R matrix generation operations and second Q matrix generation operations, respectively, and the output calculation unit outputs the decoded codeword for the R matrix that is input N-th, wherein N is an integer equal to or greater than 1.

4. The LDPC decoding apparatus of claim 1, further comprising:

a parity check storage unit storing the parity check matrix.

5. The LDPC decoding apparatus of claim 2, wherein the matrix element checking unit determines the first minimum value and the second minimum value among absolute values of the element values of each row of the first Q matrix.

6. An LDPC decoding apparatus performing LDPC decoding of a codeword formed by c code bits having soft values transmitted through a channel, the apparatus comprising:

a first Q matrix generation unit receiving the codeword and a p x c parity check matrix formed of 0 and 1 values, comparing the codeword with each of p rows of the parity check matrix formed by c elements, replacing the element having a value of 1 in each p row with a code bit value in a location of the codeword corresponding to a location of the element, and generating a first Q matrix;

an R matrix generation unit receiving the first Q matrix from the first Q matrix generation unit, and by using a first minimum value that is a minimum value among the elements that are not 0 in each row, a second minimum value that is a second minimum value in the same row, and a location of the first minimum value in each row of the first Q matrix, replacing the element that is not 0 in the row with the minimum value, and generating an R matrix;

an output calculation unit receiving the R matrix from the R matrix generation unit and by determining one code bit by adding elements of each column of the R matrix, outputting a decoded codeword formed by the c code bits;

an output determination unit receiving the decoded codeword from the output calculation unit and determining whether to output the decoded codeword by determining whether the decoding of the decoded codeword is successful using a parity check matrix; and

a second Q matrix generation unit, according to a control signal from the output determination unit determining that the decoding failed, receiving the codeword and the R matrix from the R matrix generation unit, generating a second Q matrix by replacing each non-zero element in the R matrix with a value obtained by adding all non-zero elements in a column having the non-zero element being replaced, except the non-zero element that is being replaced, and the element in the same column of the codeword P, and outputting the second Q matrix to the R matrix generation unit,

wherein the R matrix generation unit receives the second Q matrix from the second Q matrix generation unit, generates a second R matrix and outputs the second R matrix to the second Q matrix generation unit and the output calculation unit, and the output calculation unit outputs to the output determination unit the codeword decoded using the second R matrix.

7. The LDPC decoding apparatus of claim 6, wherein the R matrix generation unit comprises:

a matrix element checking unit checking the elements that are not 0 in each row of the first Q matrix, and determining the first minimum value, the location of the first minimum value, and the second minimum value; and

a matrix element determination unit receiving the first Q matrix, and the first minimum value, the location of the first minimum value, and the second minimum value of each row of the first Q matrix from the matrix element checking unit, wherein if the location is not the location of the first minimum value of the element that is not 0 in each row of the first Q matrix, the matrix element determination unit replaces the element with the first minimum value and, if the location of an element is the same as the first minimum value, replaces the element with the second minimum value, and generates the R matrix.

8. The LDPC decoding apparatus of claim 6, wherein the output determination unit determines that decoding is successful if the following matrix equation is satisfied, and outputs the decoded codeword:

$$H \cdot M = 0$$

where H denotes the p x c parity check matrix, M denotes a column matrix having the elements of the decoded codeword, and 0 is a zero matrix.

9. The LDPC decoding apparatus of claim 6, further comprising:

a parity check storage unit storing the parity check matrix.

10. The LDPC decoding apparatus of claim 7, wherein the matrix element checking unit determines the first minimum value and the second minimum value among absolute values of the element values of each row of the first Q matrix.

11. The LDPC decoding apparatus of claim 8, wherein if decoding is continuously failed as a result of a determination on whether decoding is successful using the R matrix, the output determination unit outputs the decoded codeword that is input N-th, wherein N is an integer equal to or greater than 1.

12. An LDPC decoding method of LDPC decoding a codeword formed by c code bits transmitted through a channel, the method comprising:

receiving the codeword and a p x c parity check matrix formed of 0 and 1 values;

comparing the codeword with each of p rows of the parity check matrix, the rows formed with c elements;

replacing each element having a value of 1 in each p row with a code bit value in a location of the codeword corresponding to the location of the element;

generating a first Q matrix;

replacing each element that is not 0 in the row with a minimum value and generating an R matrix by using a first minimum value that is the minimum value among the elements that are not 0 in each row, a second minimum value that is the second minimum value in the same row, and the location of the first minimum value in each row of the first Q matrix; and

outputting a decoded codeword formed by c code bits by determining one code bit by adding elements of each column of the R matrix.

13. The LDPC decoding method of claim 12, wherein the replacing of each element that is not 0 in the row comprises:

checking the elements that are not 0 in each row of the first Q matrix, and determining the first minimum value, the location of the first minimum value, and the second minimum value; and

if the location of at least one of the elements that is not 0 of each row of the first Q matrix is not the location of the first minimum value, replacing the at least one of the elements with the first minimum value and, if the location of the at least one of the elements is the same as the first minimum value, replacing the at least one of the elements with the second minimum value and generating the R matrix.

14. The LDPC decoding method of claim 12, further comprising:

generating a second Q matrix by replacing each non-zero element in the R matrix with a value obtained by adding all non-zero elements in a column having the non-zero element being replaced, except the non-zero element that is being replaced, and the element in the same column of the codeword P, and providing the second Q matrix, wherein

the replacing of each element that is not 0 in the row, the determining of the one code bit, and the generating of the second Q matrix are performed with a predetermined frequency, and outputting the decoded codeword for the R matrix that is input N-th, wherein N is an integer equal to or greater than 1.

15. The LDPC decoding method of claim 13, wherein in the checking of the elements that are not 0 in each row of the first Q matrix, the first minimum value and the second minimum value are determined among absolute values of the elements of each row of the first Q matrix.

16. An LDPC decoding method of LDPC decoding a codeword formed by c code bits transmitted through a channel, the method comprising:

receiving the codeword and a p x c parity check matrix formed of 0 and 1 values;

comparing the codeword with each of p rows of the parity check matrix, the rows formed with c elements;

replacing each element having a value of 1 in each p row with a code bit value in a location of the codeword corresponding to the location of the element;

generating a first Q matrix;

replacing each element that is not 0 in the row with a minimum value and generating an R matrix by using a first minimum value that is the minimum value among the elements that are not 0 in each row, a second minimum value that is the second minimum value in the same row, and the location of the first minimum value in each row of the first Q matrix,;

calculating a decoded codeword formed with c code bits by determining one code bit by adding elements of each column of the R matrix; and

determining whether decoding of the decoded codeword is successful using the parity check matrix, and if the decoding is successful, outputting the decoded codeword.

17. The LDPC decoding method of claim 16, wherein the replacing of each element that is not 0 in the row comprises:

checking the elements that are not 0 in each row of the first Q matrix, and determining the first minimum value, the location of the first minimum value, and the second minimum value; and

if the location of at least one of the elements that is not 0 of each row of the first Q matrix is not the location of the first minimum value, replacing the at least one of the elements with the first minimum value and, if the location of the at least one of the elements is the same as the first minimum value, replacing the at least one of the elements with the second minimum value and generating the R matrix.

18. The LDPC decoding method of claim 16, further comprising:

if it is determined that the decoding failed, generating a second Q matrix by replacing each non-zero element in the R matrix with a value obtained by adding all non-zero elements in a column having the non-zero element being replaced, except the non-zero element that is being replaced, and the element in the same column of the codeword P, and outputting the second Q matrix.

19. The LDPC decoding method of claim 16, wherein the decoding is successful if the following matrix equation is satisfied and the decoded codeword is output:

$$H \cdot M = 0$$

where H denotes the p x c parity check matrix, M denotes a column matrix having elements of the decoded codeword, and 0 is a zero matrix.

20. The LDPC decoding method of claim 17, wherein in the checking of the elements that are not 0 in each row of the first Q matrix, the first minimum value and the second minimum value are determined among absolute values of the element values of each row of the first Q matrix.

21. The LDPC decoding method of claim 19, wherein in the determination of whether the decoding of the decoded codeword is successful, if decoding continuously failed as a result of the determination of whether the decoding is successful using the R matrix, a decoded codeword that is input N-th, where N is an integer equal to or greater than 1 is output.

22. The LDPC decoding apparatus of claim 6, wherein the matrix element determination unit multiplies each element by a predetermined constant to generate the R matrix, and the predetermined constant is determined by $(-1)^{k}*s$, wherein a constant s is a value obtained by multiplying signs of the element values that are not 0 in each row excluding a present element, and k is a value corresponding to a number of the elements that are not 0 in each row.

23. A computer readable medium having embodied thereon a computer program to perform an LDPC decoding method to LDPC decode a codeword formed by c code bits transmitted through a channel, comprising:

receiving the codeword and a p x c parity check matrix formed of 0 and 1 values;

comparing the codeword with each of p rows of the parity check matrix, the rows formed with c elements;

replacing each element having a value of 1 in each p row with a code bit value in a location of the codeword corresponding to the location of the element;

generating a first Q matrix;

replacing each element that is not 0 in the row with a minimum value and generating an R matrix by using a first minimum value that is the minimum value among the elements that are not 0 in each row, a second minimum value that is the second minimum value in the same row, and the location of the first minimum value in each row of the first Q matrix; and

outputting a decoded codeword formed by c code bits by determining one code bit by adding elements of each column of the R matrix.

24. An LDPC decoding method of LDPC decoding a codeword formed by c code bits transmitted through a channel, comprising:

receiving the codeword and a p x c parity check matrix formed of 0 and 1 values;

comparing the codeword with each of p rows of the parity check matrix, the rows formed with c elements;

generating an R matrix by obtaining a first minimum value that is a minimum value among elements that are not 0 in each row, a second minimum value that is a second smallest value in the same row, and a location of the first minimum value; and

outputting a decoded codeword formed by c code bits by determining one code bit by adding elements of each column of the R matrix.

25. The LDPC decoding method of claim 24, further comprising:

replacing each element having a value of 1 in each p row with a code bit value in a location of the codeword corresponding to the location of the element;

replacing each element that is not 0 in the row with the minimum value among the remaining elements that are not 0 in the row; and

generating a first Q matrix, wherein the location of the first minimum value in each row is of the first Q matrix.

26. The LDPC decoding method of claim 25, further comprising:

checking the elements that are not 0 in each row of the first Q matrix, and determining the first minimum value, the location of the first minimum value, and the second minimum value; and

if the location of at least one of the elements that is not 0 of each row of the first Q matrix is not the location of the first minimum value, replacing the element with the first minimum value and, if the location of an element is the same as the first minimum value, replacing the element with the second minimum value and generating the R matrix.

27. The LDPC decoding method of claim 25, further comprising:

generating a second Q matrix by replacing each non-zero element in the R matrix with a value obtained by adding all non-zero elements in a column having the non-zero element being replaced, except the non-zero element that is being replaced, and the element in the same column of the codeword P, and providing the second Q matrix, wherein

the replacing of the element, the determining of the one code bit, and the generating of the second Q matrix are performed with a predetermined frequency, and outputting the decoded codeword for an R matrix that is input N-th, wherein N is an integer equal to or greater than 1.

28. The LDPC decoding method of claim 25, wherein in the replacing of the at least one of the elements that is not 0 in the row the first minimum value and the second minimum value are determined among absolute values of the elements of each row of the first Q matrix.